IN THE SPECIFICATION

On page 3 with the paragraph beginning on line 10, please amend the paragraph to read:

In one embodiment, a RF amplifier in a wireless communications system base station is provided with control circuitry including an amplitude bandwidth reduction module configured to modify an amplitude signal component, and a phase bandwidth reduction module configured to modify a phase signal component, respectively, of a RF input signal to be amplified. The phase bandwidth reduction module may reduce the phase component bandwidth of the input signal by, for example, based on a non-linear relationship between phase signal amplitude and input signal amplitude. For example, the phase bandwidth reduction module may ~~include a look up table (LUT) that reduces~~ reduce the phase component bandwidth of the input signal by adjusting the amplitude of the input signal to the power amplifier according to the non-linear relationship $A_{phase} = Y_{\max}((1-e^{px})/(1-e^{p}))$. The amplitude bandwidth reduction module may reduce the amplitude component bandwidth of the input signal by, for example, based on a non-linear relationship between the supply voltage to the RF amplifier and an input signal amplitude. For example, the amplitude bandwidth reduction module may include a LUT that reduces the amplitude component bandwidth of the input signal by adjusting the supply voltage VDD to the power amplifier according to the non-linear relationship $VDD = (x + be^{(-x/b)})(X_{\max})$. Both the phase component bandwidth reduction and the amplitude component bandwidth reduction can be implemented using lookup tables. The relatively wide bandwidth input signal to be amplified may be, for example, a CDMA signal, and the amplification system may include a relatively wide bandwidth CDMA amplifier using a EER process with reduced bandwidth amplitude and/or phase components to improve the amplification efficiency. The amplifier system may include a signal processing system for EER processing a CDMA input signal, using for example a digital signal processor, prior to input to an amplifier. In one embodiment, the signal processing system will control the power supply voltage and input signal of a RF

amplifier. A CDMA baseband or RF signal is input to a polar generator, which outputs an amplitude component signal and a phase component signal derived from the CDMA input signal. The amplitude component signal is modified by an amplitude bandwidth reduction module so as to be bandwidth reduced, and fed into a power supply amplifier that supplies the power supply voltage to the RF amplifier. By way of example, the power supply amplifier may be a VDD amplifier and may be preceded by a delay filter. A phase bandwidth reduction module reduces the phase component signal bandwidth using the amplitude component of the CDMA signal. For example, the phase bandwidth reduction module may adjust the phase component signal of the CDMA signal via a signal processing module so as to achieve bandwidth reduction. A bandwidth reduced phase component signal is then input to the RF amplifier as the signal to be amplified.

On page 5 with the paragraph beginning on line 14, please amend the paragraph to read:

Figures 3A and 3B are ~~is a~~ block diagrams of ~~another~~ an exemplary communication signal amplification system in accordance with the present invention(s).

On page 8 with the paragraph beginning on line 8, please amend the paragraph to read:

Referring now to Figure 1, a functional block diagram of one exemplary signal amplification system 100, constructed in accordance with the present inventions, is generally shown. The system 100 comprises a baseband or radio frequency (RF) input 102 into which a baseband or RF signal, RF_{IN}, is input, and an RF output 118 from which an amplified RF signal, RF_{OUT}, is output. In one embodiment, the system may utilize an envelope elimination and restoration (EER) procedure and the input signal RF_{IN} may be a code division multiple access (CDMA) signal. An exemplary CDMA waveform that may be input into baseband or RF input 102 is depicted in Fig. 2A. As can be seen from Fig. 2A, the input signal RF_{IN} is modulated both in amplitude and phase, and may be represented by the equation: $RF_{IN} = A(t)\cos[\omega c * t + \phi t]$,

where A is the amplitude modulation coefficient, ωc is the carrier frequency, t is time, and ϕ is the phase modulation coefficient. Without modification, amplification of the CDMA input signal RF_{IN} would be relatively inefficient due to the relatively high peak-to-average amplitude ratio of the compound signal waveform. The amplification system 100, however, is configured to amplify the input signal RF_{IN} in a more efficient manner using the EER technique with amplitude component signal and phase component signal including bandwidth reduction. To this end, the system 100 generally comprises a signal processing section 104, which may be a digital signal processor (DSP), a power supply amplifier 110, and RF amplifier 116. The signal processing section may contain a polar generator 106 ~~coupled to an amplitude bandwidth reduction module 108, a phase bandwidth reduction module 112, and a signal processing module 114~~ an amplitude bandwidth reduction module 108 and a phase bandwidth reduction module 111. The output of the amplitude bandwidth reduction module 108 may be coupled to the power supply amplifier 110. The phase bandwidth reduction module ~~112 may be coupled to the signal processing module 114. The signal processing module 114~~ 111 may be coupled to the RF amplifier 116. The phase bandwidth reduction module 111 includes a lookup table 112 and signal processing module 114.

On page 9 with the paragraph beginning on line 18, please amend the paragraph to read:

With regard to the phase component, the polar generator 106 may provide the phase ~~modulation~~ component signal S_ϕ 125 from, for example, a CDMA signal 102, to the amplifier system 100. As can be seen from an exemplary waveform of the phase component signal S_ϕ 125 depicted in Fig. 2C, in one embodiment (as in the conventional EER amplifier system) the amplitude variance of the input signal RF 102 has been removed, leaving a signal with a uniform amplitude. The phase component signal S_ϕ 125 may be equal to the phase modulated carrier $\cos[\omega c * t + \phi t]$. As will be discussed in more detail below, the amplitude of the phase

component signal S_{ϕ} 125 may be modified by the phase bandwidth module ~~112 and signal processing module 114~~ 111 using the amplitude component signal S_{ENV} 120 ~~and amplitude adjust the signal~~ so as to reduce bandwidth and improve operation of the amplifier system 100.

On page 11 with the paragraph beginning on line 15, please amend the paragraph to read:

To address the problems with the wide bandwidth of the amplitude component signal S_{ENV} 120 and phase component signal S_{ϕ} 125, the amplitude bandwidth reduction module 108 and the phase bandwidth module ~~112~~ 111 have been introduced to the amplifier system 100. For example, the phase bandwidth reduction module ~~112~~ 111 may operate to add back some of the amplitude variation to the phase signal ~~by generating a control signal $S_{con,\Delta BW}$ 135 that will reduce the phase signal S_{ϕ} 125 amplitude at points in time when the input signal 102 has low amplitude~~. As shown in Fig. 1, lookup table 112 may generate a control signal $S_{con,\Delta BW}$ 135 that will reduce the phase signal S_{ϕ} 125 amplitude at points in time when the input signal 102 has low amplitude. This control signal $S_{con,\Delta BW}$ 135 may be input to ~~a~~ signal processing module 114 with phase component signal S_{ϕ} 125 so as to output the bandwidth reduced phase signal $S_{\phi,\Delta BW}$ 140, supplied to the RF power amplifier 116 as the signal input.

On page 11 with the paragraph beginning on line 24, please amend the paragraph to read:

To this end, the amplitude of the phase signal $S_{\phi,\Delta BW}$ is preferably selected to maintain operation of the RF power amplifier 116 in saturation. In variations of the present invention, the phase bandwidth reduction module ~~112~~ 111 may receive the phase component signal S_{ϕ} 125 and add some amplitude variation prior to the signal processing module 114 or be incorporated into the polar generator 106. In any case, the phase signal $S_{\phi,\Delta BW}$ 140 will have some amplitude

variation that may be synchronized to the amplitude variations of the baseband or RF input signal. An exemplary bandwidth reduced phase component signal $S_{\phi,\Delta BW}$ 140 is illustrated in Fig. 2F.

On page 12 with the paragraph beginning on line 7 please amend the paragraph to read:

Further, the amplitude bandwidth reduction module 108 may operate to narrow the bandwidth of the amplitude component signal S_{ENV} 120 by, for example, eliminating some of the very low amplitude sharp points of the waveform to produce signal $S_{ENV,\Delta BW}$ 130. This bandwidth adjusted signal $S_{ENV,\Delta BW}$ 130 may then be used as an input signal to the power supply amplifier 110 which then will supply the RF amplifier 116 power signal. An exemplary bandwidth reduced amplitude component signal $S_{ENV,\Delta BW}$ 130 is illustrated in Fig. 2E.

On page 12 with the paragraph beginning on line 13, please amend the paragraph to read:

The bandwidth reduced amplified phase signal $S_{\phi,\Delta BW}$ may modulate the amplified bandwidth reduced envelope signal S_{ENV}' to produce the amplified RF output signal RF_{OUT}. Specifically, the bias of the RF amplifier 116 (the RF amplifier may include, for example, a power transistor such as a GaAsFET or an LDMOS, and in the case of a JFET-based RF amplifier, the bias is a drain bias V_{DD}) is varied in accordance with the amplified envelope signal S'_{ENV} 145, which is applied to the power terminal of the RF amplifier 116 as a time-varying supply voltage V_{DD}. Thus, the supply voltage V_{DD} modulates the phase signal $S_{\phi,\Delta BW}$ 140 with the supply voltage V_{DD}. One possible output waveform of the output signal RF_{OUT} 118 is exemplified in Figure 2D. As can be seen, the output signal RF_{OUT} 118 is generally an amplified replica of the input signal RF_{IN} 102.

On page 12 with the paragraph beginning on line 23, please amend the paragraph to read:

In one approach to achieve bandwidth reduction of the amplitude component signal and the phase component signal, the amplitude bandwidth reduction module 108 and the phase bandwidth reduction module ~~112~~ 111 may derive new signals from the amplitude signal S_{ENV} 120 with reduced signal bandwidths. For example, the amplitude bandwidth reduction module 108 may reduce the amplitude component bandwidth of the input signal using, for example, a non-linear relationship between the supply voltage S_{ENV} 120 and an input signal 102 amplitude. As a result, as illustrated in Figure 2E, the bandwidth adjusted amplitude component signal $S_{ENV,\Delta BW}$ 130 may have amplitude variations which are slightly less at the valley 205B of the bandwidth adjusted amplitude component signal $S_{ENV,\Delta BW}$ 130 when compared to the valley 205A of the amplitude component signal S_{ENV} 120 shown in Figure 2B. The amount of reduction in the bandwidth can be varied according to preference. In one embodiment, the amplitude bandwidth reduction module 108 may include, for example, a look up table (LUT) that reduces the amplitude component bandwidth of the input signal according to the following non-linear formula:

$$V_{DD} = (x + be^{(-x/b)})(X_{\max}) \qquad \text{Eq. 1}$$

where x is the normalized amplitude of the original signal, $X_{\max}$ is the maximum absolute amplitude of the original input signal (baseband or RF), and b is a variable parameter that determines the amount of bandwidth reduction applied to the amplitude component signal S_{ENV} 120.

On page 13 with the paragraph beginning on line 18, please amend the paragraph to read:

Further, the phase bandwidth reduction module ~~112~~ 111 may reduce the phase component bandwidth of the input signal using, for example, a non-linear relationship between the amplitude of the phase signal component ~~amplitude~~ and the amplitude of the input signal 102 ~~amplitude~~. As a result, as illustrated in Figure 2F the bandwidth adjusted phase component signal $S_{\phi,\Delta BW}$ 140 may have amplitude variations which may be synchronous with amplitude variations in the input signal 102. In preferred embodiments, the amplitude variations of the bandwidth adjusted phase signal $S_{\phi,\Delta BW}$ 140 may have magnitudes different then that of the input signal 102. In one embodiment, the phase bandwidth reduction module ~~112~~ 111 may include a look up table (LUT) 112 that reduces the amplitude of the phase component ~~bandwidth of the input~~ signal according to the following non-linear formula:

$$A_{phase} = Y_{\max}((1-e^{px})/(1-e^{p})) \qquad \text{Eq. 2}$$

where x is the normalized amplitude of the original input signal (baseband or RF), $Y_{\max}$ is the maximum absolute amplitude of the original input signal, and p is a variable parameter which determines the manner in which the amplitude of the bandwidth adjusted phase signal $S_{\phi,\Delta BW}$ 140 is created versus the original input signal amplitude. As with amplitude component signal bandwidth reduction, the amount of phase signal bandwidth reduction is a matter of preference. In this exemplary case using equation 2, the amount of phase component signal bandwidth reduction may be selected by selecting a particular value for p. Thus, the bandwidth of the phase component signal S_{ϕ} 125 is reduced by reducing the amplitude of the phase component signal S_{ϕ} 125 when the input signal 102 (e.g., CDMA signal) has low amplitude.

On page 14 with the paragraph beginning on line 13, please amend the paragraph to read:

Referring now to Figures 3A and 3B, a functional block diagram of ~~another~~ an exemplary signal amplification system 300 is shown ~~in accordance with the present inventions~~. The system

300 is configured to receive a baseband CDMA signal as an input signal 305 and output an amplified version, RF_{OUT} 118, that generally conforms to the shape of the input signal 305 waveform. In this case, the baseband CDMA signal 305 is input and output as in-phase (I) and quadrature (Q) signals for a predistortion module 310. The predistortion module 310 Q and I outputs are coupled to a rectangular to polar converter 315. The rectangular to polar converter 315 has amplitude components and phase component (polar) outputs. The rectangular to polar converter 315 amplitude component output may be coupled to an amplitude bandwidth reduction module 108 input and a phase bandwidth reduction module ~~112~~ 111 input. The rectangular to polar converter 315 phase component output may be coupled to the ~~input of a polar to rectangular converter 330. An output of the phase bandwidth reduction module 112 may also be coupled to an input of the polar to rectangular converter 330~~ phase bandwidth reduction module 111. Within the phase bandwidth reduction module 11, the amplitude component is supplied to lookup table 112, which generates a control signal that is supplied to the signal processing module 114. The phase component is supplied to the signal processing module 114. The signal processing module 114 adjusts the amplitude of the phase component responsive to the control signal from the lookup table 112.

On page 15 with the paragraph beginning on line 2, please amend the paragraph to read:

~~Tracing the signal path for the phase component signal S_φ 125, the~~ The signal processing module 114 includes a polar to rectangular converter 330 that generates I and Q signals based on the phase component signal S_φ 125 and the control signal $S_{con,\Delta BW}$ 135 from the lookup table 112. The I and Q outputs of the polar-to-rectangular converter 330 are coupled to respective inputs of an I/Q modulator 335. An output of the I/Q modulator 335 is couple to an input of DAC 340. An output of the DAC 340 is coupled to a low pass filter (LPF) 345. An output of the LPF 345 is coupled to an upconverter 350. An output of the upconverter 350 is coupled to

the signal input of a RF amplifier 116. The output of the RF amplifier may be coupled to a sensor 375 that provides RF_{OUT} 118 feedback to the predistortion module 310. The upconverter 350, shown in Fig. 3B, may include in series a first up mixer 352 coupled to a first band-pass filter (BPF) 360, the first BPF 360 coupled to a second up mixer 362, and the second up mixer 362 is coupled to a second BPF 370. The first up mixer 352 may be driven by a local oscillator 355 and the second up mixer may be driven by a local oscillator 365. The first BPF 360 may be, for example, a SAW filter.

On page 16 with the paragraph beginning on line 14, please amend the paragraph to read:

The phase bandwidth reduction module ~~112~~ 111 processes the amplitude component signal S_{ENV} 120 to generate~~s~~ a control signal $S_{CON,\Delta BW}$ 135 that can adjust the amplitude of the phase component signal S_{ϕ}. The control signal $S_{CON,\Delta BW}$ 135 is fed to polar-to-rectangular converter 330. The polar-to-rectangular converter 330 takes the phase component signal S_{ϕ} 125 and the phase bandwidth reduction control signal $S_{CON,\Delta BW}$ 135 and produces I and Q bandwidth adjusted phase component signal in rectangular format. These I and Q signals are then converted by the I/Q modulator 335. The digital output signal of the I/Q modulator 335 is converted to an analog signal and fed to a low-pass filter (LPF) 345. LPF 345 filters the analog signal and outputs it to the upconverter 350. The upconverter 350 takes the bandwidth reduced phase component signal and increases its frequency from baseband to RF. For example, the baseband frequency may be MHz and the first up mixer 352 may increase the signal with a 150 MHz local oscillator 355 to produce a combined 160 MHz signal. This 160 MHz frequency signal is then filtered with BPF 360. The filtered 160 MHz signal may be increase in frequency further to 1960 MHz by the second up mixer 362 having a 1800 MHz frequency signal provided by the second local oscillator 365. This 1960 MHz signal is filtered by second bandpass filter 370 to

become bandwidth reduced phase component signal $S_{\phi,\Delta BW}$ 140 that is input as the signal input to RF amplifier 116.

On page 17 with the paragraph beginning on line 7, please amend the paragraph to read:

Referring now to Figure 4, a functional block diagram of another exemplary signal amplification system 400 is shown ~~in accordance with the present inventions~~. The amplification system 400 is similar to the amplification system 300 and is configured to receive a baseband CDMA signal as an input signal 305 and output an amplified version, RF_{OUT} 118, that generally conforms to the shape of the input signal 305 waveform. Likewise, the communication system 400 may include bandwidth reduction modules 108 and ~~112~~ 111 for reducing the bandwidth of the amplitude component signal S_{ENV} 120 and the phase component signal S_{ϕ} 125 respectively. However, the phase signal processing path of this embodiment is configured so as to convert the bandwidth reduced I and Q signals to analog signals prior to I/Q modulation into a composite signal. As such, the I output of the polar-to-rectangular converter 330 coupled to an input of DAC 405A and the Q output of the polar-to-rectangular converter 330 is coupled to an input of DAC 405B. An output of DAC 405A is coupled to an input of a LPF 410A and an output of DAC 405B is coupled to an input of a LPF 410B. The outputs of LPF 410A and LPF 410B are coupled to the I/Q modulator 415. Finally, the output of the I/Q modulator is coupled to the input of an upconverter 420.

On page 17 with the paragraph beginning on line 22, please amend the paragraph to read:

In the embodiment of Figure 4, the up converter includes only a single up mixer 423 and a single BPF 430. Further, the embodiment of Figure 4 has the advantage of being able to use a slower DAC clock rate than the embodiment of Figure 3 for the same bandwidth CDMA signal. Therefore it is possible to create wider bandwidth signals using the embodiment of Figure 4 for a given DAC technology. On the other hand, the embodiment of Figures 3A and 3B has the

advantage that the I/Q Modulator is digital and, therefore, very accurate. The analog I/Q Modulator in Figure 4 has both amplitude and phase imbalance, which distorts the signal and creates memory effects that limit the effectiveness of predistortion.

On page 18 with the paragraph beginning on line 6, please amend the paragraph to read:

The operation of this embodiment is in most respects the same, the amplification system uses the EER technique to convert a baseband CDMA signal 305 into an amplitude component signal S_{ENV} 120 and phase component signal S_{ϕ} 125. The amplitude component signal S_{ENV} 120 is bandwidth adjusted by amplitude bandwidth reduction module 108 and the phase component signal S_{ϕ} 125 is bandwidth reduced via a ~~control signal~~ $\cancel{S_{CON,\Delta BW}}$ ~~135 derived from the amplitude component signal~~ $\cancel{S_{ENV}}$ ~~120~~ phase bandwidth reduction module 111. The amplitude bandwidth reduction module 108 and phase bandwidth reduction module ~~112~~ 111 may operate using non-linear equations, such as those shown in previously mentioned Eq. 1 and Eq. 2, respectively. The operation of the embodiments using these equations will now be explained in more detail.

On page 18 with the paragraph beginning on line 15, please amend the paragraph to read:

If the previously describe embodiments include an amplitude bandwidth reduction module 108 and/or a phase bandwidth reduction module ~~112~~ 111 that operate using Eq. 1 and Eq. 2, respectively, they are inherently adjustable using the variables b and p. It is worth noting that although the embodiments have been explained having both an amplitude bandwidth reduction module 108 and a phase bandwidth reduction module ~~112~~ 111, the amplification system may include either one of these modules or both modules.

On page 18 with the paragraph beginning on line 21, please amend the paragraph to read:

Referring to Figure 5, if the amplifier system includes a phase bandwidth reduction module ~~112~~ 111 that operates according to Eq. 2, $A_{phase} = Y_{\max}((1-e^{px})/(1-e^{p}))$ then the control signal $S_{CON,\Delta BW}$ 135 will operate to produce a bandwidth adjusted phase signal $S_{\phi,\Delta BW}$ 140 that varies in a non-linear manner according to the curves shown, depending on the selection of a value for variable p. For example, if p = -4, the phase signal amplitude will vary as shown by curve 510 so as to have almost no amplitude variation at higher amplitudes (i.e., normalized CDMA input signal amplitude x = 1 to 0.5) and significant amplitude variation at lower amplitudes (i.e., normalized CDMA input signal amplitude x = 0 to 0.5). If p = -2, the phase signal amplitude will vary as shown by curve 515 so as to have a reasonable amount of amplitude variation at both higher amplitudes (i.e., normalized CDMA input signal amplitude x = 1 to 0.5) and with slightly more amplitude variation at lower amplitudes (i.e., normalized CDMA input signal amplitude x = 0 to 0.5). For reference, lines 505 and 520 are provided. Line 505 illustrates the conventional EER phase signal amplitude without bandwidth reduction that shows no phase signal amplitude variation regardless of amplitude variation of the CDMA input signal amplitude. Line 520 illustrates phase signal amplitude variation if the phase signal variation tracks the CDMA signal amplitude variation exactly (i.e., for p = 0 the phase signal would have the same amplitude variation of the CDMA input signal).

On page 20 with the paragraph beginning on line 7, please amend the paragraph to read:

Referring to Figure 7, the bandwidth reduction equations are illustrated for one preferred embodiment having both an amplitude bandwidth reduction module 108 and a phase bandwidth reduction module ~~112~~ 111 in which the amplitude bandwidth reduction module 112 has variable. b = 0.1 (line 710) and phase bandwidth reduction module ~~112~~ 111 has variable p = -3 (line 705). Again, line 505 represents the conventional EER phase component signal S_{ϕ} 125 amplitude and line 615 represents the conventional EER amplitude component signal S_{ENV} 120 amplitude

variations for changes in CDMA signal amplitude variation. At high CDMA signal amplitudes identified generally by the encircled region 725, the amplitude modulation of the amplified CDMA signal is done primarily on the power supply voltage signal S_{ENV} ' 145 (e.g., VDD) and the phase signal has almost constant amplitude. As a result, there is just enough to keep the power transistor in the RF amplifier 116 saturated. This helps maximize efficiency. At low CDMA amplitudes identified generally by the encircled region 720, the amplitude modulation is done on the phase signal $S_{\phi,\Delta BW}$ 130 and the power supply voltage signal S_{ENV} ' 145 (e.g., VDD) is almost constant. This increases dynamic range of the amplifier system and reduces many of the problems with operating the power supply amplifier (e.g., VDD amplifier) at low input signal power.